4.4 Test Procedures

Spectrophotometer tests should be performed carefully according to instructions outlined in Sections 4.4.1 to 4.4.4. The instrument should be at temperature equilibrium when the tests are conducted.

4.4.1 Mercury Lamp Tests

The wavelengths falling on slits S_2, S_3 and S_4 may change because of slow deformation of the spectrophotometer main frame casting or a shift of some of the optical components. To determine whether the Q-setting table in use is applicable (i.e., that ozone observations are being made on correct wavelengths), mercury lamp tests are performed. A mercury lamp supplied with the instrument can be fixed above the inlet window to illuminate slit S_1. For routine checks it is sufficient to measure the value of Q_1 when the effective mercury wavelength 3129 A.U. falls centrally on slit S_2. Tests should be conducted at different temperatures in order to check on the temperature dependence of the Q-lever settings. The test procedure is as follows:

> Note: Avoid looking at the mercury lamp directly as it has a dangerous spectrum of light.

(1) Light the mercury lamp, using a regulated voltage source (if possible), and leave it to warm up for 5 minutes.

(2) Place the ground quartz plate above slit S_1.

(3) Turn on the spectrophotometer power supplies, and set the photomultiplier sensitivity step switch for minimum sensitivity.

(4) Place the mercury lamp over the inlet window to illuminate the ground quartz plate.

(5) Set the wavelength selector rod for SHORT wavelengths and turn the spectrophotometer dial to 300 degrees (or as far as it will go in the counter-clockwise direction). (This means that effectively only slit S_2 is open and that the microammeter deflection will be a measure of the light passing through it.)

(6) Set Q_1 and Q_2 levers for the mercury 3129 A.U. wavelength using the instrument's Table Settings of Q

(7) Adjust instrument sensitivity so that the microammeter reads approximately 14 to 18 microamperes. (If a reversing switch is not built into the microammeter, it may be necessary to reverse connections to the microammeter.) If the microammeter deflection is

too great with the sensitivity switch set for minimum instrument sensitivity, the intensity of the light entering the spectrophotometer may be decreased by placing one or two small pieces of lens tissue paper over the ground quartz plate. Alternatively, a permanent light attenuator may be installed within the Hg lamp housing. The microammeter deflection should not be reduced by means of the microammeter shunt, since, if this is done, the amplifier may be overloaded and no longer linear.

Comment: There are very sensitive instruments, and powerful mercury lamps.

(8) Read and record the temperature of the instrument to the nearest 0.1 degree.

(9) Adjust Q_1 to give maximum microammeter reading.

(10) Move the Q_1 lever upward to reduce the microammeter reading to one-half the maximum value. Read and record this value of Q_1.

(11) Move the Q_1 lever downward to give, again, the one-half maximum microammeter deflection, but on the other side of the maximum. Read the record Q_1.

(12) The mean of the readings Q_1 from (10) and (11) denotes the setting of the Q_1 lever at which the mercury line 3129 A.U. will fall centrally on S_2. Record this mean value.

(13) Repeat (9) to (12) four more times. Mean Q_1 values should agree to within about 0.2 degree.

(14) Read and record the temperature of the instrument.

(15) Deduce and record the overall mean values of Q_1.

(16) Using the Table of Settings of Q, read and record the setting of Q_1 for the Hg-3129 A.U. line at the mean temperature of the instrument. Note and record the ambient pressure if available.

(17) Obtain the difference between the Q_1 values from (15) and (16). The difference should be less than 0.3 degree of Q. If it is found to be greater than 0.3 degree:

a) If using a glass thermometer with a mercury column for instrument temperature, closely examine the column for breaks. Correct or replace if necessary. Then repeat the test.

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b) Repeat the mercury lamp test a day later, making certain that the spectrophotometer is at temperature equilibrium. If the difference in Q values persists, it should be interpreted to mean that something has happened to the spectrophotometer so that the Table of Settings of Q used with the instrument is no longer valid. If the change was sudden, and large (greater than 1 degree), contact a Dobson instrument expert (web site). If the problem persists, steps must be taken to correct the Table of Settings of Q in order to ensure that future ozone observations are made on correct wavelengths. Instructions for correcting an erroneous Q setting table are given in Appendix B.

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Deleted: Try correcting the problem by removing the spectrophotometer cover and checking to see that the bridge containing the optical wedge is securely bolted down. (Prior to removing the cover, perform a standard lamp test (see Section 4.4.2)).

4.4.2 Standard Lamp Tests

Standard lamp tests are performed to confirm that the level of calibration of the spectrophotometer has remained constant. Also, when a permanent change occurs in the spectral characteristics of the instrument, the lamp test data may be used to determine corrections to be applied to ozone data.

Tungsten-halogen lamps (e.g., 8.33 ampere, 24 volt, 200 watt lamps manufactured by G.E.C. Ltd., P.O. Box 17, East Lane, Wembley, Middlesex, England HA 9-7PG) are most suitable for use in performing standard lamp tests. This specific bulb is no longer available, but similar lamps are available from other manufacturers. A small number of these bulbs, as well as Specifications for fabricating holders for the lamps may be obtained from the NOAA CMDL, Boulder, Colorado. (The specifications are based on a lamp holder design by R. A. Olafson of the Canadian Atmospheric Environment Service, Downsview, Ontario). It is recommended that these lamps be operated at 24.0 volts d.c. with the lamp voltage monitored accurately and held stable to within ±0.1 volt in order that spectrophotometer dial reading errors not exceed 0.1 degree.

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Deleted: A limited number of standard lamp units (each comprising two lamps, a lamp holder, and a d.c. power supply with a digital voltmeter) are maintained in stock at the NOAA Air Resources Laboratory, Boulder, from which they are available through the WMO to ozone observatories that are unable to procure them elsewhere

The tungsten-halogen lamps may also be operated at a current of 8.33 amperes a.c., with the current held constant to within ±0.03 ampere. This mode of operation requires the use of a high quality, expensive dynamometer for measuring the current. Other lamps are currently in use for conducting standard lamp tests, e.g., ultraviolet light transparent glass envelope tungsten lamps operated at 100 volts a.c., similar lamps operated at 200 volts a.c., etc.

Each spectrophotometer should be supplied with at least three standard lamps referred to in the following instructions as lamps A, B, C, etc. Prior to initial use, each lamp should be operated at the rated voltage for 24 hours in order that its spectral characteristics become stabilized. Lamp tests should be performed from month to month using the same standard lamp, e.g., lamp A. Lamp B should be kept in reserve and used only occasionally as a check on test results obtained with lamp A. When lamp A burns out, lamp B should be used for all standard lamp tests, and lamp C employed for check tests, etc. Obtain a replacement for lamp A.

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A standard lamp test should be conducted immediately after the mercury lamp test has been performed. It is important to position the lamp above the instrument in exactly the same way each time, particularly with reference to lamp filament orientation. Read the temperature of the instrument to the nearest 0.5 degree Celsius and set the Q_1 lever stops for A and D pair wavelengths according to values given in the Table of Settings of Q. The Q_2 lever stops are always set to the values given in the table corresponding to the temperature of 15℃. The Q-settings for the C pair wavelengths are determined in a similar matter.

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The method of reading the R-dial position is dependent on the level of automation of the instrument. The reading in the standard lamp test should mimic the reading during normal observations.

The test procedure is as follows:

(1) Place the ground quartz plate in its usual position over the inlet window.

(2) Fix the standard lamp in correct position within the holder, and place the lamp unit over the spectrophotometer inlet window. A cover should be used to shield the lamp and ground quartz plate from other bright light, e.g., daylight. As a further precaution, standard lamp tests should always he conducted indoors rather than outside in broad daylight. Otherwise, the daylight may affect the lamp readings appreciably even with the lamp partially covered with the lamp cover. It is recommended that a vertical shield be attached at one end of the lamp to shield the lamp from direct eye contact of the lit lamp. The quartz lamp emits ultraviolet so viewing directly is not recommended.

(3) Adjust the lamp voltage or current to the correct value, using a regulated power source for the AC input to the power supply, if possible. Leave the lamp alight for at least 5 minutes.

(4) Push the S4 shutter rod (left hand rod) all the way into the spectrophotometer base. The wavelength selector rod should be set to SHORT (fully out) position when measurements are made on A, C, and D wavelengths, and to LONG position when C' wavelength measurements are made.

(5) With the power off to the instrument, Check the mechanical zero of the microammeter, and correct if needed.

(6) Set Q1 and Q2 levers for A- pair wavelengths according to the data given in the Table of Settings of Q. The Q1 setting is determined by reading the intruent temperature, and finding in the Q1 value for the A-pair

(7) Increase the microammeter sensitivity by turning the shunt potentiometer fully clockwise. Increase instrument sensitivity as needed.

(8) Check and adjust the lamp voltage or current. Turn on the Dobson power switches.

(9) Obtain and record a reading of the R-dial position.

(10) Set for C, C', and D pair wavelengths, in succession, checking the lamp voltage at each setting, obtaining and recording a reading of the R-dial position for each pair.

(11) Repeat (6) to (10) two more times.

(13) Compute the mean values of the dial readings for A, C, C' and D wavelengths.

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(14) Compare the experimental mean data obtained with reference data for the same lamp given in the instrument's table entitled Reference Standard Lamp Data and the historical record of the standard lamp results. Experimental values of RA, RC, and RD should not differ from reference values by more than ±1.0 degree, and RC' values should agree to within ±2.5 degrees.

(15) If the experimental data do not agree with the reference data within the limits specified in (14), the following action should be taken:

(a) Wash the ground quartz plate with soap and water, dry it, and replace it in its holder.

(b) Check condition of the silica gel. Replace with dry silica gel, if needed.

(c) Perform standard lamp tests a day later using lamps A, B and C. If the discrepant standard lamp readings persist, contact a Dobson expert for advice..

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(d) Remove the spectrophotometer cover with instrument power off and in subdued light. To prevent accidental damage to the spectrophotometer photomultiplier tube, place a piece of black electrical tape over slit S5.¶
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(e) Remove the bridge unit containing the optical wedge and inspect it for cleanliness. An air squirt should be employed to blow away dust and lint from the wedge. If additional cleaning is required, it is recommended that "dry" cleaning be attempted by breathing on the quartz surfaces and polishing with pure lens tissue paper. (Lens tissue paper commonly employed in cleaning eye glasses must not be used since it is impregnated with oil that may not be transparent to ultraviolet radiation.) Always use a fresh piece of lens tissue paper when touching a normally unexposed optical surface. Take care not to exert too much pressure on the optical wedge sections since they may break away from their holders if the glue holding them in place is brittle. If a persistent film remains, clean the optical surfaces with a piece of lens tissue paper lightly moistened with alcohol, and then dry clean. Care should be exercised not to use too much alcohol since it may affect the binding material used in construction of the optical wedge sections. Also, the black paint used on the instrument casting is slightly soluble in alcohol and may smear around the optical components.¶
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(f) Examine other optical surfaces, e.g., the Q plates, lenses, mirrors, inlet window, etc. Clean the surfaces, if necessary, as in (e). Mirrors should NOT be cleaned with alcohol except as a last resort (see Section 5.9). The mirrors are front aluminized and are easily scratched. An air squirt may be used to rid the mirrors of dust and lint.¶
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(g) Replace the spectrophotometer cover after first removing the tape from slit S5, and perform another set of standard lamp tests one or two days later using all standard lamps. (Use of the spare lamps will indicate whether a real change has occurred in the spectral characteristics of the instrument, or whether the spectral characteristics of the first lamp have altered.)¶
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(h) If the standard lamp tests conclusively prove that the spectral characteristics of the spectrophotometer have changed, corrections to the instrument's NA, NB, NC, and ND tables must be determined; also, appropr… [1]

(d) Remove the spectrophotometer cover with instrument power off and in subdued light. To prevent accidental damage to the spectrophotometer photomultiplier tube, place a piece of black electrical tape over slit S5.

(e) Remove the bridge unit containing the optical wedge and inspect it for cleanliness. An air squirt should be employed to blow away dust and lint from the wedge. If additional cleaning is required, it is recommended that "dry" cleaning be attempted by breathing on the quartz surfaces and polishing with pure lens tissue paper. (Lens tissue paper commonly employed in cleaning eye glasses must not be used since it is impregnated with oil that may not be transparent to ultraviolet radiation.) Always use a fresh piece of lens tissue paper when touching a normally unexposed optical surface. Take care not to exert too much pressure on the optical wedge sections since they may break away from their holders if the glue holding them in place is brittle. If a persistent film remains, clean the optical surfaces with a piece of lens tissue paper lightly moistened with alcohol, and then dry clean. Care should be exercised not to use too much alcohol since it may affect the binding material used in construction of the optical wedge sections. Also, the black paint used on the instrument casting is slightly soluble in alcohol and may smear around the optical components.

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(g) Replace the spectrophotometer cover after first removing the tape from slit S5, and perform another set of standard lamp tests one or two days later using all standard lamps. (Use of the spare lamps will indicate whether a real change has occurred in the spectral characteristics of the instrument, or whether the spectral characteristics of the first lamp have altered.)

(h) If the standard lamp tests conclusively prove that the spectral characteristics of the spectrophotometer have changed, corrections to the instrument's NA, NB, NC, and ND tables must be determined; also, appropriate corrections must be applied to "back" ozone data. The procedure to be used in determining corrections to the N tables is outlined in Appendix E.

(16) It is expected that the need for more than one standard lamp test per month will arise rarely. Also, it should not be necessary to clean the optics according to instructions given above more often than about once per year. Removal of the instrument cover for cleaning of optical components should be minimized